

Infrared scanning of sprocket holes

The invention relates to a film scanner comprising a first scanning device for scanning frames of a cinematographic film by means of photoelectric transducers, and a second scanning device for scanning the sprocket holes. The invention also relates to scanning devices as such and to a method of scanning the sprocket holes in a
5 cinematographic film.

To convert cinematographic film material into electronic signals, a film in a film scanner is passed along or through an opto-electronic scanning device. This poses the long-standing problem of maintaining the frame position of successively scanned frames constant. The partly periodical, partly statistic fluctuations of the frame position, which are referred to as picture steadiness errors or film weave, may have different causes. These
10 errors may be, for example positioning errors in both the pick-up camera and in the negative/positive copying machine. However, also frame position errors and tracking errors of the film scanner may lead to further steadiness errors.

To reduce picture steadiness errors, there are different formulations for solutions as described, for example, in DE 38 19 496 C2 in which a sprocket hole which is assignable to a film frame is scanned by means of a cathode ray generated by a cathode ray tube and serves as a reference point for each scanned frame. Dependent on the position of a sprocket hole determined in this manner, a correction signal for correcting the horizontal lateral irregularity is generated. Here, the problem is encountered that in given film material
15 the quantity of light passing through the film is approximately the same as the quantity of light transmitted through the sprocket hole. This problem occurs, for example in negative film material which has an orange basic color. To solve this problem, it is proposed to use green-sensitive photocells for scanning the sprocket hole in this case, because these cells, as compared with the red and blue sensitive photocells, supply a signal with the smallest
20 electronic interference.
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A problem in film scanners with optical scanning of the sprocket hole is that the first scanning device for scanning the film frames may be disturbed by light scattered by the second scanning device for scanning the sprocket holes. In fact, the operations of scanning the sprocket holes and scanning the frame are preferably performed simultaneously

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at the same location, which presupposes a narrow spatial proximity of the areas where light occurs and passes through for detecting the sprocket holes and for scanning the frames. It is ensured only by the narrow spatial and temporal proximity of the two scanning operations that the offset errors determined during the operation of scanning the sprocket holes also
5 correspond to the offset errors of the scanned frames. However, such a spatial proximity led to problems with scattered light in known scanning operations.

It is therefore an object of the invention to provide a scanning device in which the scanning device for scanning film frames is not disturbed by the scanning device for scanning sprocket holes.

10 This object is solved in that the spectral sensitivities of the first and second scanning devices are chosen to be such that they lie in maximally different spectral ranges. This can be achieved, for example in that the photoelectric transducers of the first scanning device, which are sensitive when scanning color films in the red, green and blue spectral range, are chosen to be such that they have relatively narrow spectral sensitivities. If
15 a light current whose color spectrum does not coincide with any of the photoelectric transducers of the first scanning device used for scanning the film frame is used for illuminating or transilluminating the sprocket hole, light scattered onto the photoelectric transducers of the first scanning device by the light current used for scanning the sprocket hole can no longer cause any disturbance.

20 If the film frame and the sprocket hole are illuminated by means of a common light source, the light spectrum of the light current used for illuminating the sprocket hole can be obtained by an optical filter inserted in the radiation path of this light current. Another solution is to illuminate film frame and sprocket hole by means of two light sources, using light sources with different light spectra. Similarly, the spectral sensitivity of
25 the photoelectric transducers can be obtained by filters preceding the photoelectric transducers.

It is a further object of the invention to provide a film scanner and a scanning device for a film scanner by means of which the edges of sprocket holes can be determined as accurately as possible.

30 This object is solved in that, for illuminating the sprocket holes, a light source is provided whose light spectrum lies in the infrared spectral range, and in that the photoelectric transducer provided for scanning the sprocket hole is sensitive in the infrared range.

It has surprisingly been found that when illuminating with infrared light or

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light which comprises infrared spectral components, the scanning signal obtained in the infrared spectral range has an attenuation maximum in the area of the edge of the sprocket hole so that the edge can be detected in a particularly simple manner. The cause of this attenuation maximum seems to be that a change of material occurs at the area of the edges of the sprocket hole during the punching process. This change of material becomes manifest by a reduction of the material transparency in the infrared spectral range.

An infrared light-emitting diode is particularly suitable as a light source.

The invention has the further advantage that, due to the illumination or transillumination of the sprocket hole with infrared light only, problems of scattered light in the frame sensors are obviated. Since the (color) frame sensors are selectively sensitive in the red, blue and green spectral range, infrared light scattered by the light source for scanning the sprocket holes does not affect the frame scanning process to such an extent as an illumination of the sprocket hole with light in the visible spectrum. For the case where the sensors provided for frame scanning should also be sensitive in the infrared spectral range, this problem can be very easily solved by an infrared cut-off filter preceding the frame scanning sensors.

These and other aspects of the invention are apparent from and will be elucidated with reference to the embodiments described hereinafter.

In the drawings:

Fig. 1 shows a film scanner,

Fig. 2 shows a transmission curve of a sprocket hole in the infrared range,

Fig. 3 shows an arrangement of CCD line sensors.

Fig. 1 is an embodiment of a film scanner with its essential parts and their co-operation with a detector circuit according to the invention for detecting sprocket holes. A film 1 is fed from a supply reel 2 in the direction of the arrow 3, via a capstan 4 to a take-up reel 5. Supply reel 2, capstan 4 and take-up reel 5 are driven by means of electromotors 6, 7, 8 which are controlled by a film feed control device 9. To this end, the film tension is measured by means of a first sensor lever 11 which is arranged in the film drive path proximate to the supply reel 2. The measured film tension is applied to the film feed control device 9 which controls the supply reel motor 6 by means of an internal control circuit in such a way that a possibly constant film run is ensured. By means of a second sensor lever

12 arranged proximate to the take-up reel 5, the film tension is similarly controlled via the take-up reel motor 8 in the film take-up process. Various guidance rolls 10 predetermining the film drive path of the film 1 are arranged in the path of the film.

For optically scanning a film 1, the film 1 is guided by means of a swivable guidance roll 13 in such a way that it partially winds around the capstan. The film feed rate is thereby exclusively predetermined by the capstan 4 and its capstan motor 7.

To control the film feed rate during scanning, a sprocket 15 rigidly connected to a tacho-disc 16 is arranged as a speed sensor in the film drive path. The tacho-disc 16 supplies pulse signals (hereinafter referred to as tacho-pulses) in conformity with the film speed, which pulses are applied to the film feed control device 9. Dependent on parameters set by means of an operating panel 17 and the tacho-pulses supplied by the tacho-disc 16, control signals for driving the capstan motor 7 are generated.

During film feed, the film 1 is passed through a scanning unit 18 in which the film 1 is illuminated by means of an illumination device diagrammatically shown as a lamp 19 and a condensor 20. The light which is modeled by the image contents of the film 1 is scanned via frame scanning sensors 21, 22, 23 and 24. The first scanning sensor 21 is used for scanning a luminance signal W, and the other scanning sensors 22, 23 and 24 are used for scanning the chrominance component signals RGB. Luminance signal W and chrominance component signals RGB are applied to a video signal processing unit 25 in which the received signals are converted into the desired video signal format and are available in a studio standard at an interface 26.

Before the film 1 is opto-electronically converted in the scanning unit 18, it passes through an arrangement for detecting picture steadiness errors. In this embodiment, this arrangement is constituted by a second illumination device 27 on one side of the film 1, a sprocket hole sensor 28 on the other side of the film and a computing unit 29. A line camera which may be added as an independent unit, is also suitable as a sprocket hole sensor 28. The imaging optics of such a camera should preferably have telecentric properties because scanning points located in the depth of field of the optical system can be imaged without changing the criteria. Movements of the film perpendicularly to the film plane thus do not cause any errors within the depth of field of the optical system when the deviation of the frame position is computed.

A further possibility is to use a CCD line sensor as sprocket hole sensor 28. Fig. 3 shows, for example an arrangement consisting of four CCD line sensors, in which the first three line sensors 31, 32, 33 are sensitive in the red, blue and green spectral range

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(the individual cells are denoted by "o"), and a fourth sensor 34 which is sensitive in the infrared spectral range (whose individual cells are denoted by "X"). It is also feasible to use other arrangements in which the CCD line sensor has infrared-sensitive cells only in the range of the sprocket holes to be expected, in which the infrared-sensitive cells are combined with a high-resolution detail sensor, or CCD line sensors which are separated for the right and left sprocket hole.

The computing unit 29 evaluates the output signals of the sprocket hole sensor 28 and generates correction signals C for horizontal and vertical picture steadiness errors, which signals are applied to the video signal processing unit 25. By means of the correction signals C, each individual video frame can be offset in its horizontal and vertical position in known manner during the signal conversion and the relevant picture steadiness error can be corrected.

Since the sprocket holes assigned to a frame are generally produced in a punching process, the geometrical dimensions of the holes assigned to each frame are constant. In the embodiment, the sprocket hole is illuminated with an infrared light source, for example an infrared diode for scanning the sprocket hole and scanned with an infrared-sensitive line sensor. An infrared cut-off filter 30 which is transmissive in the range of visible light is arranged between the scanned film 1 and the scanning sensors 21, 22, 23 and 24. In this way, it is avoided that the light used for illuminating the sprocket hole disturbs the scanning sensors 21, 22, 23 and 24.

Fig. 2 is a longitudinal section through a film material 1 with areas 31 in which the film material has a normal transparency. Areas 32 in which the transparency of the film material is decreased due to the punching process, and the area 33 of a sprocket hole. Pictured below it is the output voltage U_s of the sprocket hole sensor 29 at the same position in the film feed direction. The change of the signal variation is preferably detected by means of a differentiator circuit. Fig. 2 shows the relevant pulsatory signal peaks 34, 35 obtained by means of a gradient method and applied as scanning values to the computing unit 29.